# Effects of the Expanded National Route Program on Management of the National Aviation System

Philip J. Smith*
Elaine McCoy**
Judith Orasanu***
Rebecca Denning*
Amy Van Horn**
Charles Billings***

* Cognitive Systems Engineering Laboratory
The Ohio State University
Columbus, OH 43210

** Department of Aviation
Ohio University
Athens, OH 45710

*** NASA Ames Research Center
Moffett Field, CA 94035

As part of our studies of the interactions of airline operations control centers (AOCs) with the air traffic management system, we have assembled teams to visit a set of AOCs and TMUs. These teams were composed from an airline air traffic coordinator, a former air traffic manager, two pilots and two aviation human factors researchers. The purpose of these visits was to observe, interview and collect data relevant to the following questions:

1.      What is the impact of the expanded National Route Program (NRP) on the functioning and interactions of AOCs and TMUs?
2.      What implications do these findings regarding the expanded NRP have for guiding future decisions about the architecture of the National Aviation System?

In conducting these analyses, a particular emphasis is being placed on the human factors implications and issues.

In order to provide timely access to our findings, we are first distributing memos such as this which simply list preliminary observations. It should also be recognized that many of these "observations" are really hypotheses, as they are based on limited input and data at this point. As the study is completed, these will be merged and organized into a more cohesive report. This memo is a result of visits to the Chicago and Cleveland TMUs.

**Observation 1**. <u>The source of the major concerns is not the expanded NRP per se; it is the spinoffs of the expanded NRP</u>, such as the increase in direct routes, the decrease in the use of preferential routes, and the cancellation of restrictions and procedures contained in advisory circular 90-91. The impact is that flights are now going direct through sectors where they previously were not direct. The problem is that the complexity in sectors has increased with NRP and Non-NRP aircraft going direct. The major change in air traffic patterns isn't due to flights filed under the new expanded NRP itself, as fewer than 5% of the flights are being filed under the new expanded NRP. It is due to the spinoff of the expanded NRP.

The "old" NRP (advisory circular 90-91) has several pages of restrictions, restricting flights to certain preferential routes, at specific peak times of the day. With the expansion of the new NRP, these route restrictions were canceled and the use of the preferential routes has decreased. Mile-in-trail restrictions were also removed. Cleveland, for example, always had a 20 mile-in-trail restriction, at specific times, for flights landing in Newark. All flights to Newark were sequenced by Chicago Center over Carlton. This restriction is now canceled. The flights to Newark now come through Chicago on various routes, often through different sectors on different days reference the wind, regardless of whether they are NRP or Non-NRP. Some pilots request direct routes and some controllers clear them on direct routes without any approval from the next sector. This is interpreted by some controllers as the "Free

Flight" concept. This is being accomplished by amending flights to file direct after they are airborne. As a result, maintaining the big picture in terms of sequencing and impact is much more difficult.

The net result is that 70 to 80% of the flights over many centers are now on direct routes. For some centers, such as Kansas City and west, this isn't a major problem. For others like Chicago and east, there is significant impact. Some aircraft have held at the Chicago Center, Cleveland Center, and Indianapolis Center boundaries because sequencing multiple flows becomes nearly impossible.

**Observation 2.** <u>A related problem is that, when a flight is relabeled as NRP while enroute, the controllers who must deal with it later in its flight have no way of knowing whether or not it was filed under the expanded NRP.</u> This creates problems, as those controllers then have "no way of policing those flights, because if it says NRP it means we're not supposed to reroute them. We're supposed to leave them alone."

Question: Flights that are currently labeled as NRP on their flight strips can differ in terms of 3 dimensions. First, a flight labeled as NRP may or may not be following the flight plan that was originally filed prior to takeoff. (The latter case arises with flights that have been amended while enroute). Second, this NRP flight plan may or may not have been coordinated with ATCSCC (depending upon whether it was filed under the expanded NRP or the "old" NRP procedure as defined in advisory circular 90-91). Flights amended while enroute similarly have not been coordinated with ATCSCC. Third, the basis for developing a particular flight plan could have been for reasons of efficiency or weather avoidance.

Given these very different types of flight plans, it might be useful to create separate designations for flights filed:

1.    under the expanded NRP (NRP-F for "Free flights");
2.    through the Command Center as a request to fly a non-preferred route to improve efficiency (NRP-CE for "Coordinated Efficiency flights");
3.    through the Command Center as a request to fly a non-preferred route for weather avoidance (NRP-CW for "Coordinated Weather avoidance flights");
 4.    Refiled direct while enroute (NRP-A for "Airborne amendment flights").
            Since this category wasn't actually intended to exist under the orders for the expanded NRP, it might be preferable to remove the NRP designation completely and label it something like AD for Airborne Direct.

Separate designations for these four situations could be useful for both real time control decisions as well as for evaluative purposes where it would be helpful to be able to determine the relative effects of these four categories of what are currently labeled "NRP" flights.

Another question is whether the new and expanded NRP should encompass all previous programs like the "Direct Routes Program," the "Preferential Routes Program", the "Wind Routes Program", the old "NRP" program, and "Static Restrictions" under one umbrella. Then there would be only one program to refer to. The use of certain "Preferential Routes" at certain times could be mandatory. Certain "Static Restrictions" would be approved and specified, the use of "Direct Routes" would be defined, reference coordination and approval requirements with the ATCSCC and/or other sectors, and the "New NRP" would then be a specific airline requested route program as was originally intended. This would put some structure back into what is now a set of very confusing, multiple overlapping programs.

**Observation 3.** <u>Several airline dispatchers and ATC coordinators that we talked to about Observation 1 were unaware that this was happening</u> (even with flights from their own airlines). This concerned them, as the best route in terms of fuel consumption, time, sequencing, etc. may not be the direct route. Furthermore, most pilots have neither the data nor the computer support software to determine the best route while airborne:

ATC *Coordinator*: "If a direct route had been better, I would have filed it through the NRP. For example, there was a flight that flew from DFW direct to Parker. I had planned it over Albuquerque because of a favorable southerly jetstream. Flying direct to Parker, the flight was flying directly into the jetstream. The plane was 6 minutes late."

Two solutions are available to help with this particular problem. First, dispatchers should more fully explain the reasons behind their route selections to flight crews when anything significant needs to be considered, thus helping the pilots to make more informed judgments while airborne. Second, it may be desirable for the flight crew to consult with Dispatch to take advantage of ground-based flight planning tools when a major route change is being considered.

More broadly, such concerns serve to highlight internal airline communication problems, as well as issues regarding AOC-TMU or AOC-ATCSCC interactions:

ATC *Coordinator*: "A higher level of AOC/Pilot communication is needed to ensure that pilots understand why the dispatcher has planned a flight in a particular way, and that the AOC has feedback on what is happening to flights while enroute."

ATC *Coordinator*: "The problem with the expanded NRP is that there's no feedback to the AOCs. Nobody's getting smarter. ... When we went to free flight on Jan. 9, we cut off the feedback loop for those flights filed under the expanded NRP. ... How do we get this local knowledge that the TMUs and controllers have out there for the dispatchers and pilots? ... There are problems in the ATC system that I don't know about. I need a mechanism to get feedback. ... How do we give the airlines more

timely information?  Depending on where they're going on which day, how do we get the information to everybody?  How do we all get the same picture?"

ATC *Coordinator*:  "ATC doesn't know what the payback is for accommodating a request for some change, while the AOC doesn't know what the impact of that change will be on traffic patterns.  As an example of the first problem, we had a flight from Minneapolis that ATC delayed because there was too much traffic at the higher altitudes.  ATC assumed that the airline would prefer to wait until a high altitude route was available, as this would save on fuel.   Later investigation showed, though, that the flight could have flown at FL 180 at a price of about 300  pounds of extra fuel consumption.  This cost would clearly have been preferable, compared to the approximately $5000 loss from 101 misconnecting bags due to the delay.  What the airline needs is a choice: High and 10 minutes late or low and now? ... How do we become more interactive?"

ATC *Coordinator*:  "Offer the operator some options: Which way do you want to do this - delay the flight or fly further to get there closer to on time?"

ATC *Coordinator*:  "What seems to have happened is that the ATC system has been designed to talk to the airline only through the pilot.  That's often too late."


**Observation 4.**  A possible solution to the two problems identified in Observations 1 3 would be to:

a.  Continue to allow flights to be filed (pre-flight) under the expanded NRP as originally intended, which includes allowing AOCs to file direct flights when that is what is "best" for the airline.  This would likely reduce the total number of direct flights (and some of the sector saturation problems that ATC is experiencing), as it appears that some (and perhaps many) of those that are currently the result of flight amendments made by the pilots and controllers while enroute (Observation 3) may not actually be better than the originally filed route.

b.  Allow a flight amendment to be made by the pilot and controller, changing to a direct route while enroute, but only if that amendment has been approved by all of the affected Centers.  (In the past, this was standard procedure for approving such direct routes.)  As part of this process, the flight crew should be encouraged to consult with Dispatch for the reasons stated in Observation 3.  This could reduce the sector saturation problems if some of the direct flights that are currently being approved are in fact less desirable than the originally filed route.

c.  Work on methods to handle greater numbers of direct flights, and to develop a streamlined method to approve direct flights while enroute that ensures that later sectors in the flight are not saturated.

This return to a previous procedure would buy time to develop better methods for AOCs to indicate to flight crews whether changing to a direct route while enroute would be desirable.  It would also buy time for the traffic management system to develop procedures to accommodate increases in direct flights that are filed while enroute.  Equally important, implementing this solution would eliminate the current confounding that makes it impossible to really assess the impact and benefits of the expanded NRP because of the large number of direct flights that are being filed while enroute.

*Caution*: There is considerable disagreement among airline staff about the desirability of such a change.  Some dispatchers appear to feel that, if they could file user-preferred trajectories for all flights, then:

1.  If a direct flight was recommended by the airline ground-based flight planning system as best, they would file it pre-flight;

2.  Unless conditions have changed, there would be no reason for a flight crew to change to a direct route while enroute, if the original route was something other than direct.  (The argument is that, if a direct route had been best, it would have been filed and, since conditions haven't changed, the original route should have been best);

3.  Flight crews should be given an explanation by the dispatcher indicating why a direct flight was not filed pre-flight, so that the crew can better judge whether conditions have changed sufficiently to warrant consideration of a change to a direct flight while enroute.

Other airline staff, on the other hand, argue that about 80% of the time a direct flight is better than the original route and, consequently, given the opportunity, the flight crew should usually accept a direct flight if it is offered by ATC.

Given this apparent (strongly felt) divergence of views, and given the lack of any data to evaluate these views, further exploration with a broader spectrum of the airline and ATM/ATC community is needed to be able to assess the desirability, as well as the reaction of the airlines, to proposals 4a, 4b, and 4c above.  If possible, objective data should also be collected to evaluate these viewpoints.

In addition, it is worth noting that these viewpoints may not actually be opposing one another.  The latter perspective expressed above may be based on past experience in which most flights were forced to fly the standard pref route, rather than a user-preferred trajectory, so that a direct flight often was preferable.  Furthermore, that basis may still hold true for many flights, since only a limited number can be and are being filed preflight on the user-preferred trajectory under the expanded NRP or through a request to ATCSCC for a non-preferred route, and since some airlines don't have the tools to develop plans for direct flights during pre-flight planning.  Consequently, it is not clear that all airline staff would support the idea of limiting

changes to direct flights in order to help make it possible to continue lowering the altitudes accommodated under the expanded NRP.

In short, the issue of how the airlines should deal with filing direct flights, as well as how the ATM/ATC system should deal with such requests, is a complex matter that merits further study.

**Observation 5.** The congestion resulting from high sector loading can result in inefficiencies (such as high altitude holding) that can eat up benefits in those cases where a direct flight would otherwise have been more efficient.  The lack of real time information about such potential bottlenecks makes it difficult for the dispatcher to make an informed decision about whether or not to recommend to a flight crew that they refile direct even if that dispatcher is consulted by the flight crew.

**Observation 6**.  From a traffic management perspective, the issues raised in Observations 2 and 3 are important, as "sometimes not flying direct makes a big difference in optimizing the use of the airspace and has little impact on fuel."  In such a case, it is in the interests of everyone involved to leave the flight on its original route. These data seem to indicate the need for much better coordination within airlines and among the airlines, TMUs and ATCSCC.

**Observation 7.**  At some Centers, the expanded NRP itself is raising some issues.  As an example, one challenge arising from the expanded NRP is that airlines sometimes want to cross their high altitude flights over departure and arrival routes.  For instance, for certain flights over the top of O'Hare, the Center has always preferred that the traffic be routed over Badger in order to avoid having enroute traffic cross the departure lanes.   One airline, however, would prefer (and has now been filing) these flights over Iowa City-Waterloo under the expanded NRP.  Such flights criss-cross through the departure lanes, creating a "very tricky, complex operation" for ATC.

This scenario raises a difficult tradeoff:  Do you let 3 or 4 planes cross at the cost of slowing departures by about 20%?  This tradeoff is particularly interesting given such flights would most often be slowing departures from Chicago of flights by two other airlines.

*Question*:  What policies and procedures are followed in deciding this tradeoff?

*Question*:  Are there solutions to reduce this problem (both short and long run)?  One solution that has been suggested is to redesign the sectors involved so that they  are "not so long, not so narrow." (Does this imply that one of the reasons this scenario is a concern is because of the effect on an individual controller's workload?).


A second, related solution that is being explored is to establish superhigh sectors for the enroute traffic, so that the flights "climbing to altitude won't be dodging these guys

going East-West."  This latter solution was just being implemented on the day of our last visit to Chicago Center, with the creation of 3 new superhighs.

Another solution would be to identify those areas where restrictions are actually needed, and to instate or reinstate such restrictions:

TMO:  "How do we provide O'Hare with the required miles-in-trail with free flight?  We have to be able to feed O'Hare with some type of a predictable route.  I don't know if they'll ever be able to do it without an arrival route."

TMO:  "We're inundated with direct routes on the south side of the Center.  Most of the traffic never used to impact sectors on the south side.  Are they going to allow me to restrict them at certain times?"

TMO:  "I don't think that it is unsafe.  What we have are airplanes crisscrossing through sectors where they haven't before.  We're handling it, but we've had to react instead of plan, design and be ready for it."

ATC *Coordinator*:  "A global perspective is important in revising a flight plan.  There may be a perception that a restriction is unnecessary while a plane is early in the flight, but you then hit a wall at a later point.  You're better off with a 10 degree

turn over Joliet instead of 40 degrees over Niagara Falls and then another 40 degrees to get sequenced at Slate Run."

ATC *Coordinator*:  "At some point, paying for flexibility isn't economical.  If flexibility increases capacity, then there's a benefit."

TMO:  "With ASD, we have eyes beyond our boundaries.  But it gets cumbersome because the NRP program says you're not supposed to touch them.  So we have to move 3 or 4 other airplanes to solve one problem.  They [the Command Center] encourage you to move other traffic to leave the NRP traffic alone."

ATC *Coordinator*:  "If a flight hits a bottleneck because it was filed using the expanded NRP, it may cost us more money, not less.  I'd rather be slowed at Chicago than holding at Slate Run. ... We may be trying to optimize the enroute portion, but at the same time de-optimizing the arrivals."

TMO:  "As another example, we ended up moving 3 NRPs up to the northwest arrival fix to land.  It would have been cheaper for them to file to the northwest fix to begin with."

ATC *Coordinator*:  "Someone has to be responsible for identifying and communicating constraints and bottlenecks, so that the air traffic management system and the AOCs can respond to them effectively."

One approach to dealing with bottlenecks is to set constraints up in such a way that the airline is given flexibility in deciding how it wants to deal with allocations, such as deciding which flight it wants to use to fill an allocated "slot", or deciding what route it wants to follow to get to an allocated arrival time at a particular arrival fix:

ATC *Coordinator*:  "If the slot was up to ATC and the route was up to the airline, then they could tactically adjust to hit that time, reducing the burden on the controller: 'You're time at Blue Ridge is 1025 Z.'  You could even offer them alternatives, 2 different fixes."

A second example that is arising as a direct result of the expanded NRP at some airports, and also as a result of the increased numbers of direct flights, has to do with balancing of loads at cornerposts:

For example, "if we get a jetstream right out of the southwest part of the country, everyone rides it [into O'Hare].  75 percent of these airplanes are all coming in at the southwest cornerpost, creating a major volume saturation point.  The old solution was to create a delay program to avoid launching too many flights into traffic, for example creating 20 minute delays at an airport, and to [increase capacity by moving] half a dozen flights to the northwest cornerpost.  [Under the expanded NRP] we're not allowed to do this because of free flight.  If they [the airlines] create the bottleneck, then they have to live with it."

Another situation that has specifically arisen due to the expanded NRP has occurred when one particular airline "has 5 flights which originate in the LA Basin, PHX and LAS.  When they all file to the Southwest cornerpost at DTW during certain arrival banks, the result is an overload at that fix.  We respond by moving a couple of those flights, or other flights originating in Florida, to another fix."

*Question*:  How is the excess saturation dealt with now once it arises?

*Question*:  Are there short or long run solutions to increase capacity and/or predictability (to allow the airlines to make more informed decisions), thus reducing this as a problem?

*Question*:  How aware are the airlines of this problem, and how are they dealing with it?  (In order to encourage the airlines to make effective decisions, we need to give them feedback about those flights that seriously impact the efficiency of the air traffic system.)

*Question*:  Since the flight strips simply list a flight as NRP, how can they (the TMUs and controllers) even tell whether a flight is filed under the expanded NRP?

A third example of an issue associated with the actual expanded NRP concerns what is happening when there are arrival rate restrictions (due to weather, etc.). For instance, in one case Kennedy had set a reduced arrival rate of 50 percent at 2 p.m. because of the weather forecast. To deal with this, Chicago Center began limiting flights bound for Kennedy that were flying the standard pref routes. In addition, however, there were flights filed under the expanded NRP that were not limited. The net result was that the capacity for Kennedy was exceeded, with many planes "winding up in high altitude airborne holding, and that's a major problem."

**Observation 8.** The assumption behind free flight is that "if the airlines create a bottleneck and for 3 days in a row they get delayed, they'll change. They'll change the departure time or file a different route. [Under free flight, we're] leaving it up to them to find a solution." The assumption, in other words, is that free flight represents a "free market" environment in which businesses will respond to problems in order to remain competitive.

*Question*: This leaves it up to individual airlines to find individual solutions. What about cases where the best solution would require coordination of flights across airlines? How could such coordination to be requested or provided? (Should organizations like the ATA play such a role?)

*Question*: What can be done to help ensure timely detection and resolution of such problems by the airlines? The experience of TMUs is that the airlines "are often very reactive and not real timely. They get pounded a lot before recognizing there's a recurrent problem." How can we improve communications to ensure that the appropriate individuals within the airline are aware of these problems, so that they can respond more effectively?

**Observation 9.** Problems with information exchange also exist in terms of the communication of policies and recurrent problems (i.e., information that doesn't deal with more immediate, real-time decisions just prior to or during a particular flight). In particular, TMOs may speak with airline AT Reps rather than ATC Coordinators and Chief Dispatchers. It was clear from our visits that valuable information is being communicated to the AT Reps, but may not make it through the various airline levels to the air traffic coordinators and dispatchers.

TMO: "We recently had a meeting with the Chief Dispatcher from one of the airlines. That was one of the most productive meetings we've ever had. We could say: What do you want and we could work it out in 2 hours. Getting the right level of people together - it opens the communication door."

**Observation 10.** The TMUs also have a problem with getting adequate feedback and information:

TMO: "We don't even get a listing of who flew NRP the day before so we can review it and see what are the trends."

TMO: "I don't see why every morning the airlines don't call and say: 'We're sending 20 extra planes on this route.' Then I'd know."

ATC *Coordinator*: "With some additional automation, giving you that preliminary route data would be quite possible for some airlines. From an airline perspective, knowing how that information will be used is important, though. It has to be used in an appropriate fashion or the airlines won't be willing to provide it."

**Observation 11.** Some FAA policies and procedures actually discourage open communication. One such case (and there are several other similar cases) arises when there's a ground delay program at an airport:

"The incentive is to not tell Central Flow about your canceled flights. If you provide such data, they'll penalize you. If you tell them about your canceled flights and they subsequently run a ground delay program, those flights are removed from ATC's flight list and they are no longer available slots that your airline can use for other still operating flights."

To solve such problems, better ground-to-ground communication is required, as well as changes in traffic flow management procedures.

**Observation 12.** One of the challenges that needs more study and consideration is how to accommodate the wide variations in the practices of different airline AOCs.

**Observation 13.** The expanded NRP is sometimes causing unpredictable changes in controller workload:

"One day a controller is inundated, the next day he's twiddling his thumbs."

*Question:* What strategies are available to deal with this? ("We could adapt to shifts in the jet stream by changing the staffing per areas. The way sectors are designed in Centers, they're very rigid. Under the free flight concept, that doesn't work very well. We need to look at a much larger piece of airspace, with flexible airspace to deal with flexible traffic."

**Observation 14.** "Another problem is the design of sectors and center boundaries. The center boundaries and the old preference route system contribute to the problem, limiting flexibility. To make changes, though, the airlines, unions and environmental groups will have to be involved. Maybe with GPS, maybe navigation can change so the sector boundaries are not such a big deal anymore. And if they [the aircraft] could participate in their own separation, that would take a lot of the burden off the controller."

**Observation 15.** "One of the big problems is that every time you run a plane along a boundary, you've got 2 controllers who have to keep cognizant of it. You're doubling up the workload."

**Observation 16.** Another potential challenge is with commuter flights. With aircraft like the Challenger jets, "they want to go to 37,000 feet." How will this traffic be handled if they start to take advantage of the expanded NRP?

**Observation 17.** "The difference in enroute Centers are really quite unique."

*Question*: To what extent do solutions have to be adapted to meet the requirements of different centers.?

**Observation 18.** "Some of the dispatchers, flight crews and controllers don't understand the concept of the NRP."

*Question*: What could be done to improve their understanding and awareness?

**Observation 19.** The AOCs need a tool to do real time what-ifs that consider predicted traffic densities, restrictions, etc.

**Observation 20.** The monitor alert system is not adequate. The experience of the TMUs visited is that: "It doesn't help us to predict the overloads."